Effect of Lime Concentration on physical properties on the Raw & Developed Pumpkin Petha and Cost Analysis of prepared Petha

Abstract

This study investigates the effect of varying lime concentrations (5%, 7.5% and 10%) on the physical properties of raw and developed pumpkin petha and analyses the cost of production for the prepared petha. Lime concentration plays a critical role in the texture, volume and overall acceptability of petha, a traditional Indian sweet made from pumpkin. The research evaluates the impact of these lime treatments on the firmness, water absorption and structural integrity of both raw and developed petha samples. The results indicate that 7.5% lime concentration consistently led to optimal textural properties in the final product, yielding petha with the best firmness and volume retention. Petha treated with 5% lime concentration exhibited a softer texture and higher water absorption, resulting in a less desirable structure. Conversely, the 10% lime-treated petha showed increased firmness, but with an overly rigid texture and reduced consumer acceptability. The study highlights that the intermediate lime concentration (7.5%) strikes a balance between maintaining the structural integrity of the raw pumpkin and developing the desirable texture of the final petha product. In terms of cost analysis, the research considers raw material costs, including pumpkin, lime, sugar and labor expenses, along with packaging and storage costs. The data reveal that while 7.5% lime-treated petha has a slightly higher initial production cost due to the optimal processing conditions required, it yields the highest overall acceptability and consumer preference, justifying the cost. The study concludes that 7.5% lime concentration is the most effective for producing high-quality pumpkin petha, providing the best balance between texture, consumer acceptability and long-term storage stability. The research underscores the importance of optimizing lime concentration to maximize the economic viability and marketability of pumpkin petha.

Keywords: lime concentration, pumpkin petha, firmness, texture.

Introduction

Pumpkin (*Cucurbita spp.*), a member of the Cucurbitaceae family, is a widely cultivated vegetable known for its versatility, nutritional value and economic significance.

Native to North America, pumpkin has spread globally, being grown in diverse climates across Asia, Europe and Africa **(Paris, 2000)**. The fruit is rich in vitamins, minerals and antioxidants, making it a valuable component of both traditional and modern diets. Pumpkin's nutritional profile includes high levels of beta-carotene, a precursor of vitamin A, which plays a crucial role in promoting eye health and boosting the immune system **(Kim *et al.*, 2012)**. In addition to its nutritional benefits, pumpkin is low in calories and contains significant amounts of fibre, which contribute to its growing popularity in health-conscious food markets. It has also been demonstrated that pumpkin has further advantages for improving spermatogenesis, wound healing, antimicrobial, anti-inflammatory, antioxidative and anti-ulcerative qualities, as well as for treating benign prostatic hyperplasia **(Batool *et al*., 2022).** Beyond its use as a food source, pumpkin is utilized in a variety of processed products, including soups, purees and sweets like the traditional Indian confection, pumpkin petha. The fruit's composition, particularly its pectin and water content, makes it suitable for processing and value addition, enabling it to serve as a key ingredient in diverse culinary traditions **(Dhiman *et al*., 2009).** The oldest pumpkin seeds were found in Mexico, dating between 7000 and 5500 BC **(Bieniek *et al*., 2014).** India occupies a prime position and is the second largest producer of vegetables next to China in the world. It is grown in an area of 1,12,000 hectares with a production of 24,00,000 MT **(2nd Advance Estimate 2022-2023).** The heaviest pumpkin recorded ever is weighed 2,249 pounds (1,246.9 kilograms). It was presented by a Horticulture teacher, Travis Gienger at the 50th Safeway World Championship **(Guinness World Records, 2023).** Pumpkins are very versatile in their uses for cooking and have an advantage over other vegetables as the fruit can be stored for up to 6 months before being consumed and hence can play an important role in maintaining nutritional levels during the long dry seasons **(Akhter *et al.*, 2012)**.

Pumpkin petha is a traditional sweet delicacy in India, made by treating pumpkin (Cucurbita moschata) with lime (calcium hydroxide), followed by cooking in sugar syrup. The preparation of pumpkin petha involves various stages of treatment, including soaking the raw pumpkin in lime water to enhance its texture and firmness, thus allowing it to withstand further cooking processes. Lime concentration plays a crucial role in determining the quality of the final product, influencing both the physical properties of raw and developed pumpkin petha. However, limited research exists on the specific impact of varying lime concentrations on the physical attributes of pumpkin petha, such as texture, firmness and volume retention, as well as the economic feasibility of its production across different treatments. The physical properties of food products, particularly those related to texture, are critical in determining consumer acceptability. For pumpkin petha, these properties are primarily influenced by the interaction of calcium ions from the lime solution with the pectin structure in pumpkin cell walls, which helps in maintaining firmness and water retention during cooking **(Rolle & Satin, 2002)**. Insufficient lime treatment can lead to a softer, less desirable texture, while excessive lime can cause an overly rigid product that lacks the tender quality associated with petha. Thus, optimizing lime concentration is essential to achieving the desired balance between firmness and softness in the final product.

Previous studies have highlighted the significance of calcium salts in fruit and vegetable processing, particularly in enhancing structural integrity during cooking and extending shelf life **(Martin-Diana *et al.*, 2007)**. However, few studies have directly addressed the specific concentrations of lime and their effects on both raw and developed pumpkin petha. This research seeks to fill this gap by systematically investigating the impact of three different lime concentrations—5%, 7.5% and 10%—on the physical properties of both raw and cooked petha, with a focus on texture, water absorption and volume retention.

In addition to physical properties, the economic aspects of pumpkin petha production are crucial for determining its feasibility at commercial scales. Cost analysis is essential to ensure that the production process remains economically viable while meeting consumer demands for high-quality products. The cost analysis in this study includes the evaluation of raw material costs, labor, packaging and storage. This study aims to contribute to the understanding of the effects of lime concentration on the physical properties of raw and developed pumpkin petha, as well as provide a detailed cost analysis of the production process. By examining the relationships between lime concentration, physical quality and production costs, this research will offer valuable insights for producers seeking to optimize both the quality and economic feasibility of pumpkin petha.

Material and Method

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The study was conducted at Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, India. The research aimed to evaluate the effect of varying lime concentrations (5%, 7.5% and 10%) on the physical properties of raw and developed pumpkin petha and to perform a cost analysis of the prepared petha. We purchased fresh pumpkins (*Cucurbita moschata*) from a nearby farm and gave them a good wash. After

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peeling and seeding, the pumpkins were sliced into pieces. For the experiment, food-grade calcium hydroxide, or lime, was purchased. Water, packing material, and refined sugar were other ingredients utilised to prepare the syrup. For several hours, the chopped pumpkin pieces were submerged in lime solutions at concentrations of 5%, 7.5%, and 10% (w/v). The pieces were properly cleaned under running water to get rid of any extra lime after soaking. After that, the prepared pumpkin pieces were cooked through by boiling them in a solution of sugar syrup. After cooking, the petha was allowed to cool at room temperature before being sealed for storage. Measurements were made of the raw and cooked petha's volume, mass, length, and other physical characteristics. Cost analysis took into account the price of labour, raw materials, energy use, and packaging. For every lime concentration and packing material, the entire manufacturing cost was determined, and the economic viability was evaluated using a cost-benefit analysis. Every experiment was carried out in triplicate using the CRD method, and an ANOVA analysis was used to see whether there were any significant changes between the treatments.

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Result and Discussion

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***Physical* properties:** Evaluating the physical properties of raw diced pumpkin and developed Petha involved examining parameters such as length, width, thickness, mass and volume. These attributes are critical in understanding the transformation that occurred during the processing of pumpkin into Petha, highlighting changes in size, weight and structural integrity. Physical characteristics like total mass of the raw diced pumpkin, length, width, thickness and volume were assessed before developing the product. Later the physical properties of developed products were evaluated treated with different concentrations of lime water (5%, 7.5% & 10%) and compared them by calculating their percentage expansion. It has been observed that the mass, length, width, thickness and volume had increased in the treated Petha (candy), as the sugar and water used for cooking made them to swell up. But here we observe that the swelling or percentage expansion was decreasing (77.47%, 71.38% and 48.76%) with increasing concentration of lime (5%, 7.5% and 10%) respectively. As increasing lime concentration made the Petha firmer and made it to penetrate less sugar and water inside the Petha. The transformation from raw diced pumpkin to developed Petha involved notable changes in physical properties. Understanding these physical changes was crucial for optimizing the processing conditions and ensuring the desired quality of the final

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product. The physical properties of raw diced pumpkin as well as developed Petha is tabulated below in Table 1 and Figure 1.

***Cost analysis*:** Conducting a cost analysis of pumpkin Petha revealed that cooking with a 5% lime concentration was more economical compared to using 7.5% and 10% lime concentrations. The primary cost components included raw materials (pumpkins, sugar and lime), energy, labor and packaging. At a 5% lime concentration, the initial cost of lime was lower costing 77.87 Rs for a 600gm sample, but the final product had a softer texture, potentially reducing its market value and shelf life. The 7.5% lime concentration offered a balanced approach, moderately increasing lime expenses while significantly improving the texture and shelf life of the Petha compared to the 5% concentration. This concentration optimized the trade-off between material costs and product quality, potentially leading to better market acceptance and reduced losses. The cost estimated for 7.5% lime treated Petha was 88.21 Rs for a sample. Conversely, using a 10% lime concentration increased the overall cost (98.55 Rs per sample), but it enhanced the firmness and durability of the Petha, reducing spoilage and wastage during storage and transportation. This higher concentration, however, required additional processing time and energy to achieve the desired quality, slightly raising the operational costs. Therefore, while the 5% concentration was cost-efficient, the 7.5% concentration stroke a balance between cost and quality, offering a potentially higher return on investment. The 10% concentration, despite its higher costs, could be reserved for niche markets where specific quality attributes command premium prices. The cost estimation of pumpkin petha revealed that the 7.5% lime concentration treatment, while slightly more expensive due to optimized processing conditions, provided the best balance between quality and economic feasibility. The higher production cost for 7.5% lime-treated petha was justified by its superior consumer acceptability and longer shelf life, particularly when stored in glass jars. The 5% lime treatment resulted in lower production costs but compromised texture, leading to potential market losses. Conversely, the 10% lime treatment increased production costs without a corresponding increase in quality, making it less economically viable **(NIFTEM 2021)**.

The Benefit Cost Ratio was computed by dividing the entire cash benefit projected by the total cash cost estimated for a project. In this project net present value of the project is equal to total market price of prepared Petha candy (Rs. 6912) and overall expense of the project is equal to total cost to prepare Petha Candy. Benefit to Cost Ratio (BCR) is computed to be 1.09. As the BCR value is greater than 1 it indicates that the project is profitable shown in Table 3.

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Table 1: Physical properties of raw diced pumpkin and developed Petha:

Physical properties												
		Raw diced pumpkin					Developed Petha					
Sample	Lime concentration	Mass (gm)	Length (cm)	Width (cm)	Thickness (cm)	Volume (cm^3)	Mass (gm)	Length (cm)	Width (cm)	Thickness (cm)	Volume (cm^3)	Percentage expansion (%)
Pumpkin Candy	5%	39.67	4.03	3.37	2.13	28.99	68.47	4.83	4.03	2.63	51.41	77.47
	7.50%	39.23	4.1	3.33	2.1	28.7	68.25	4.8	4.17	2.43	48.72	71.38
	10%	37.99	4.13	3.3	2.03	27.79	63.42	4.8	3.83	2.23	41.1	48.76

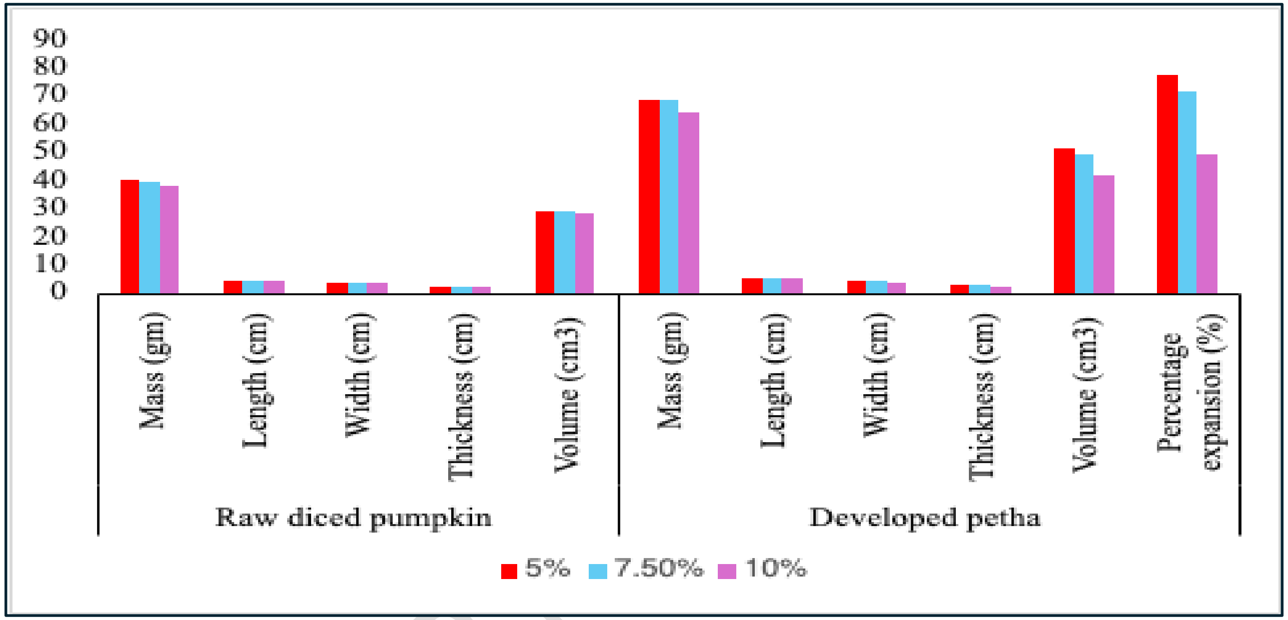

Figure 1: Physical properties of raw diced pumpkin and developed Petha

Table 2: **Cost Estimation of Developed Petha**

Cost Estimation of Developed Petha									
	Amount required for 100 gm (in g)			Cost of Pumpkin Candy in Rs.				Total Cost of 100gm in Rs.	Total Cost of one Sample (600 gm) in Rs.
Treatments (lime concentration)	Pumpkin	Sugar	Lime	Pumpkin (@Rs. 40/Kg.)	Sugar (@Rs. 45/Kg.)	Lime (@Rs. 663/Kg.)	Misce-llaneous (Rs.)		
5%	167	30	5.2	6.68	1.35	3.45	1.5	12.98	77.87
7.5%	167	30	7.8	6.68	1.35	5.17	1.5	14.70	88.21
10%	167	30	10.4	6.68	1.35	6.90	1.5	16.43	98.55

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Table 3: Calculation for BCR

No. of treatments	24
No. of replication of each treatment	3
Weight of each replication (gram)	600
Total cost of all treatments one replication each	2117
Total Cost of all replications	6351
Total weight of all replications (Kg.)	43.2
Market Price of Petha Candy (Rs. /Kg.)	160
Total market price of prepared Petha Candy (Rs.)	**6912**
Total cost to prepare Petha Candy (Rs.)	**6351**
Benefit to Cost Ratio (BCR)	**1.09**

Conclusion

The physical properties of raw diced pumpkin for petha preparation were characterized by consistent mass, length, width, thickness and volume. Typically, each piece of diced pumpkin weighed between 37.5 to 40 grams, with dimensions approximately 4 cm in length, 3-4 cm in width and around 2 cm in thickness. The volume of each diced piece average between 27-29 cm^3, providing a manageable size for processing and packaging. Petha treated with 5% lime tends to retain more moisture, resulting in slightly higher length, thickness, mass and volume. The 7.5% lime-treated Petha stroked a balance, showing moderate reductions in length, width and thickness. The 10% lime-treated Petha exhibited the most substantial reduction in physical dimensions due to the stronger dehydration effect, resulting in a denser, more compact product. The cost estimation revealed that pumpkin petha treated with 7.5% lime concentration, despite slightly higher production costs due to optimal processing conditions, offered the best balance between quality and economic viability. The superior texture and consumer acceptability at this concentration justify the investment, particularly when high-quality packaging like glass jars is used. In contrast, the 5% and 10% lime treatments, while slightly cheaper, resulted in lower overall product quality, leading to potentially reduced marketability. Therefore, 7.5% lime concentration is recommended for producing commercially viable, high-quality pumpkin petha.

Future Scope

In order to improve texture and flavour even more, future studies on the relationship between lime concentration and pumpkin petha may examine the effects of other factors as well, such as varied sugar concentrations or natural firming agents. The nutritional effects of different lime concentrations could also be studied, especially with regard to calcium content and bioavailability. Furthermore, investigating the environmental sustainability of petha production including the application of waste reduction techniques and eco-friendly packing materials could yield insightful information. Studies on long-term storage under various climatic circumstances may be able to improve preservation techniques and increase pumpkin petha's shelf life.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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